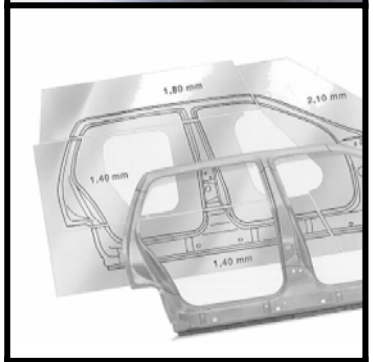
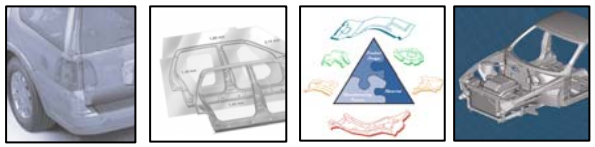


Overview: STEEL
Enabling Technologies

Dr. Roger Heimbuch
Auto/Steel Partnership

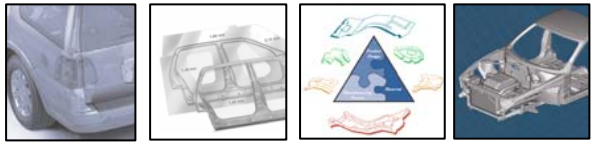
Auto/Steel Partnership

www.a-sp.org



OUTLINE OF PRESENTATION

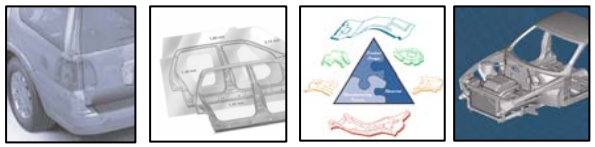
- Sheet Steel Fatigue
- High-Strength Steel Stamping
- Hydroform Materials and Lubricants
- Advanced High-Strength Steel Joining
- Tribology



Sheet Steel Fatigue

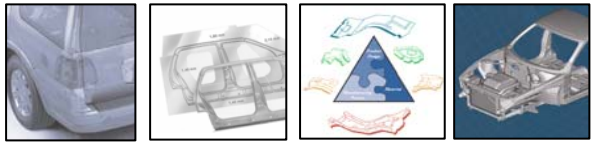
Project Manager: Bart Clark
Auto/Steel Partnership

Chair: Raj Mohan
Severstal North America, Inc.



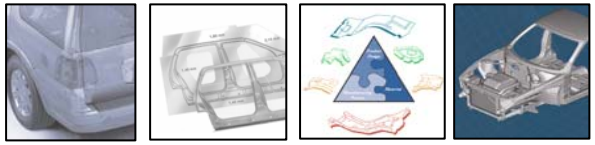
PROJECT GOALS

- Support vehicle lightweighting initiatives.
- Determine the fatigue characteristics of:
  - Sheet steels
  - Spot welds
  - Metal Inert Gas (MIG) welds
  - Lasers welds
- Evaluate and validate predictive methodologies for durability assessment.



PROJECT APPROACH

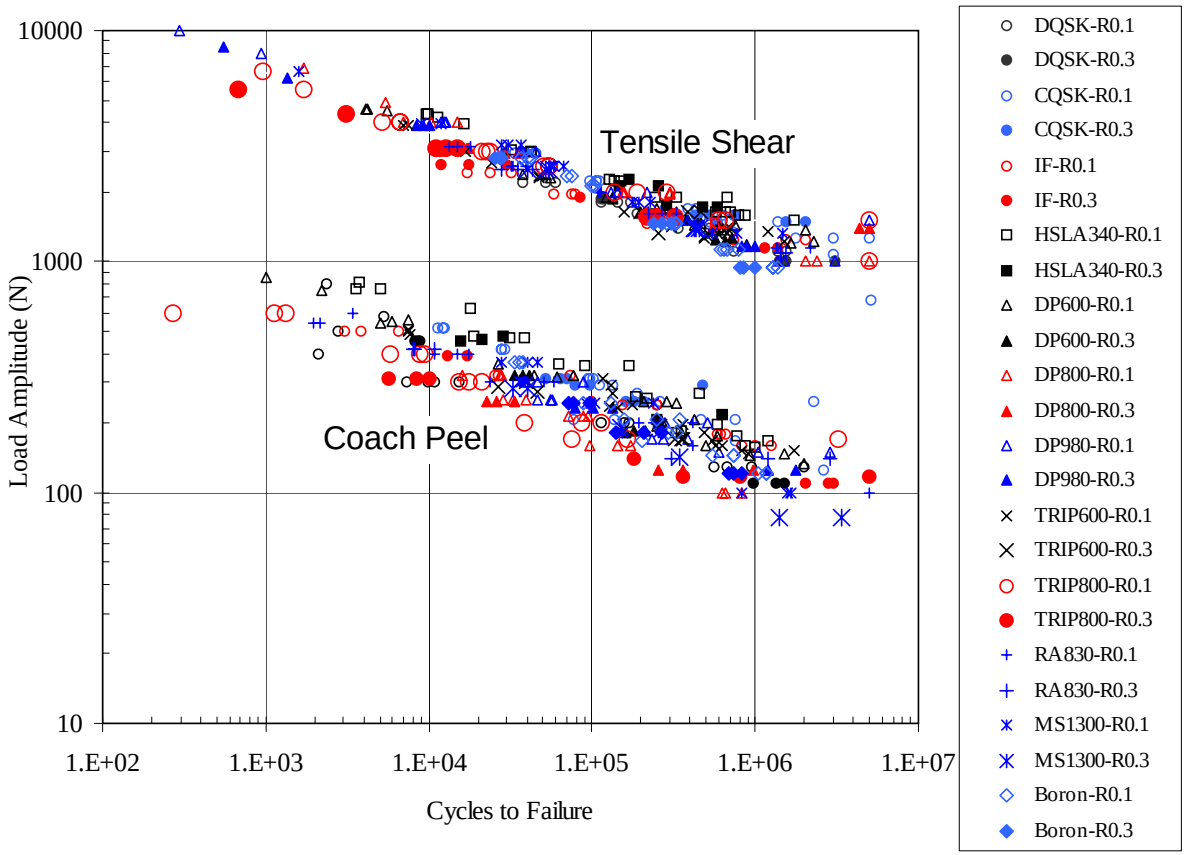
- Fabricate welded coupons from multiple grades and gages of AHSS.
- Conduct thorough fatigue testing on AHSS welded joints to determine:
  - Mechanical properties of welds
  - Fatigue responses from welds
  - Effects of geometric variation of welds on weld durability
- Investigate durability issues:
  - Dissimilar metals spot welding
  - Structural adhesives
  - Multiple spot-weld architecture

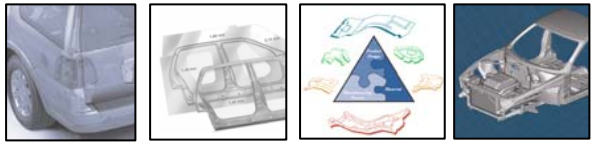


SHEET STEEL FATIGUE PROJECT RESULTS

Resistance Spot Weld (RSW) Testing

- Designed and fabricated RSW fatigue test specimens from mild steel and ultra high strength boron steel.
- Completed testing of spot welds. Placed online the knowledge base developed from the results.
- Completed a detailed study of the effect of geometric parameters on fatigue life of spot welded specimens.

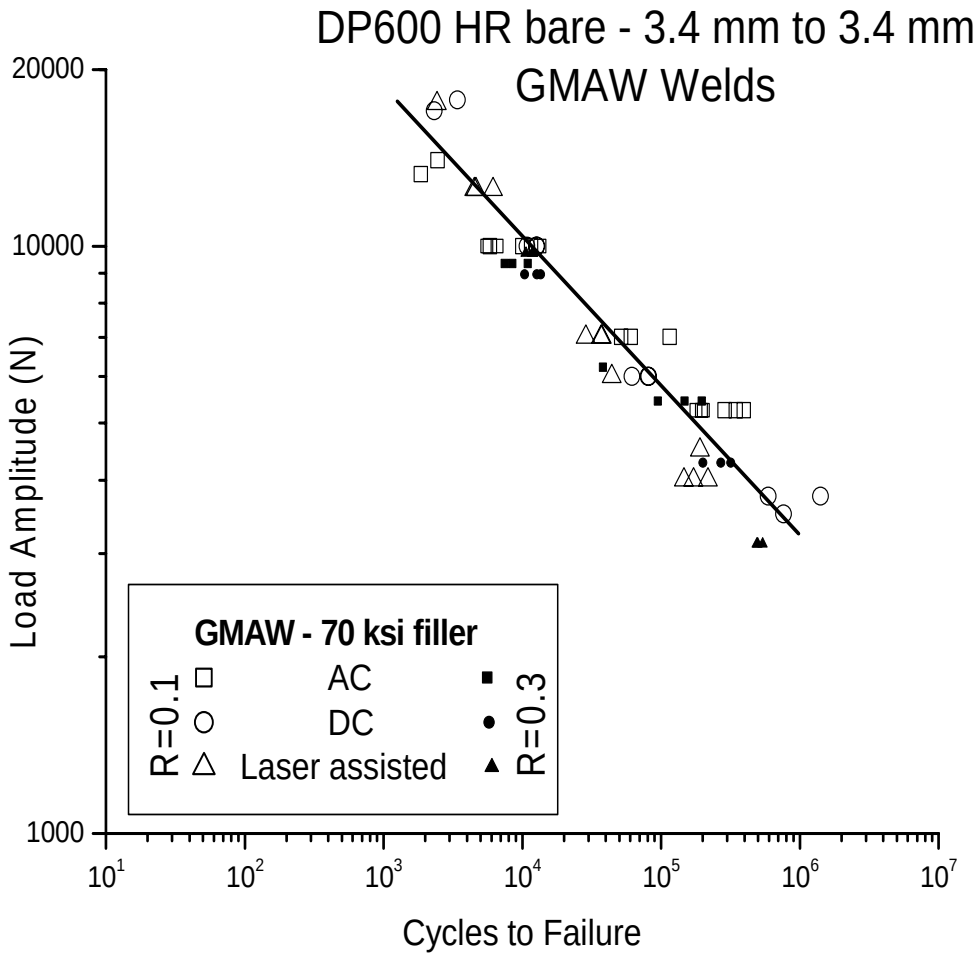


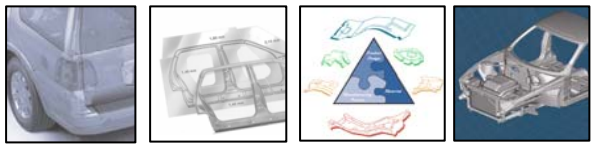


SHEET STEEL FATIGUE PROJECT RESULTS

MIG / Laser Weld Testing

- Completed fatigue testing of MIG welded specimens created by the Joining Technologies Team (ASP-070)
- Developed a specification for fabricating MIG and Laser welded specimens
- Completed weld fatigue testing of single-lap shear, double lap shear and perch-mount MIG weld specimens

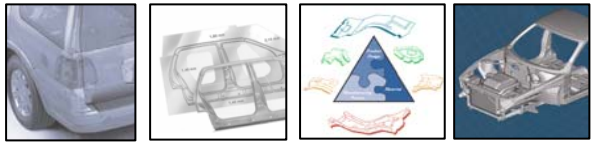




SHEET STEEL FATIGUE

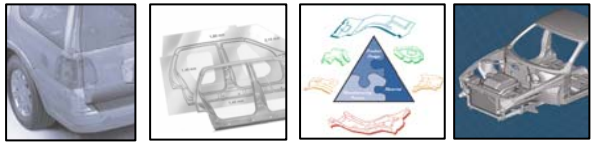
TECHNOLOGY TRANSFER

- Spot weld data available on member website
- A/SP report on spot weld project
- SAE paper & presentation
- Testing and analysis on weld fatigue completed on Joining Technology Team weld fatigue specimens
- IABC paper written on spot and GMAW welded specimens
- GDIS 2007 presentation on spot weld work.



NEXT FISCAL YEAR ACTIVITIES

- Investigation of:
  - Laser seam welds.
  - Effects of large amounts of cold work (stretch) on base metal fatigue.
  - Spot-welded (multi-weld) structural testing.



High-Strength Steel Stamping

Project Manager: Michael S. Bzdok
Auto/Steel Partnership

Co-chair: James Fekete
General Motors Corporation

Co-chair: Changqing Du
Chrysler LLC

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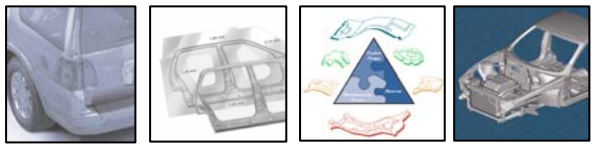
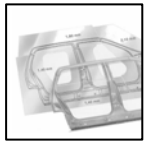
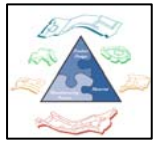


PROJECT GOALS

- Evaluate springback prediction capability.
- Validate die processes and part features for best part quality in AHSS:
  - Minimum springback/curl/twist.
  - Minimum wrinkling.
  - Improved Dimensional accuracy.
- Assess impact of AHSS on press force/energy requirements.
- Develop product/process design guidelines for AHSS.
- Characterize fracture behaviors of AHSS during stamping to guide stamping processes and steel development.


HIGH-STRENGTH STEEL STAMPING

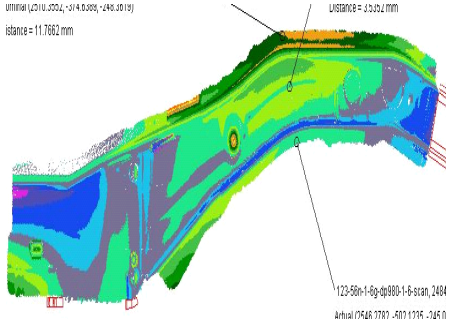
PROJECT DELIVERABLES

Experiments and Springback Measurements

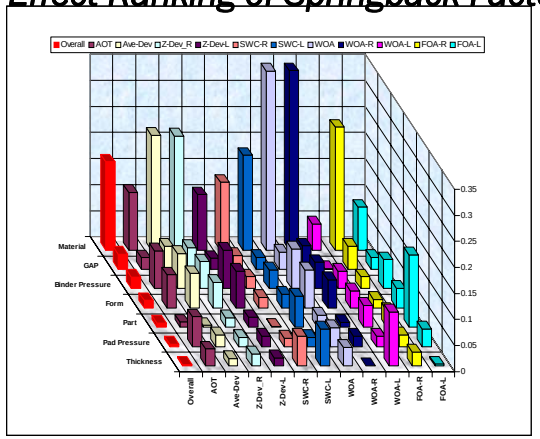
Formed Dual-Phase Rail Panel

Panel after draw process

Panel after trimming process



Effect Ranking of Springback Factors



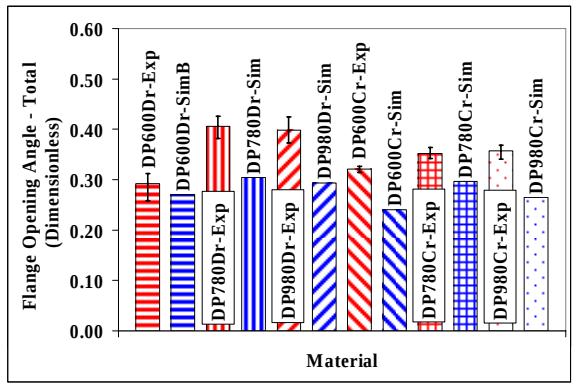
Validation of springback predictability

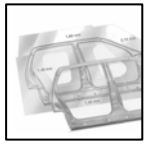
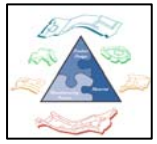
- LS-Dyna simulation

Conclusion:

- Springback increased with the material strength.
- Draw form process produced more springback than the crash form process.
- Overall, reasonably good prediction accuracy was obtained, especially for DP600 parts.

Correlation Sim. Vs. Exp.




HIGH-STRENGTH STEEL STAMPING

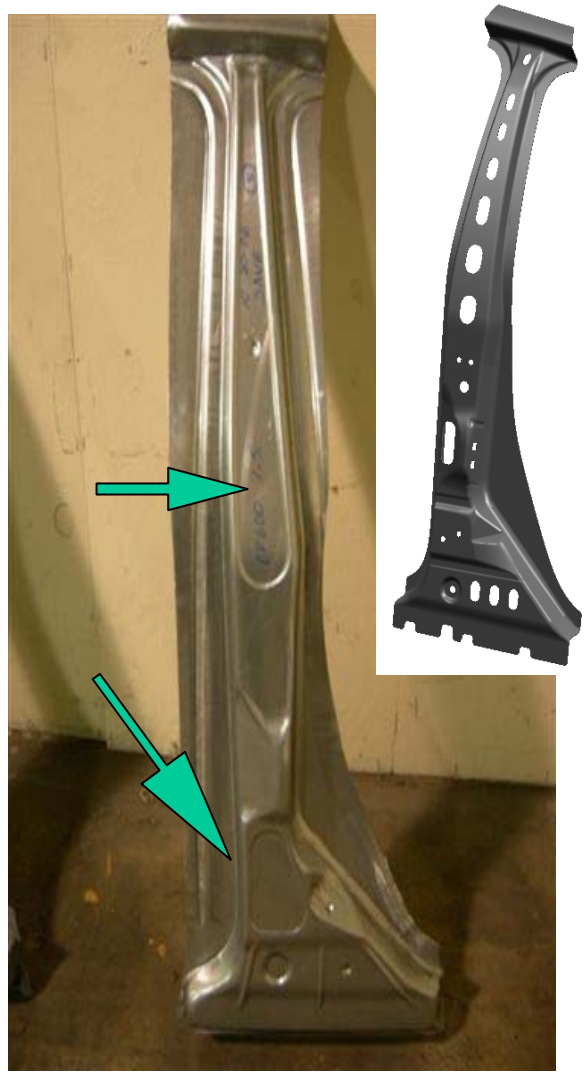
PROJECT DELIVERABLES

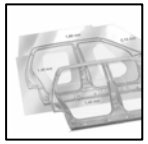
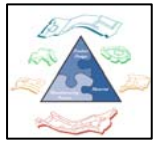
Several features added to enable stamping in DP780.

- Changes to product shape to take up excess metal.
- Features added to stiffen part.

Split/fracture free stampings made from both DP780 and DP980.

Phase II: Dimensional evaluation and evaluate computer guided compensation to re-cut die.




HIGH-STRENGTH STEEL STAMPING

PROJECT DELIVERABLES

- EWI/OSU project – ongoing three year project.
  - Characterization, Draw Bend Formability (DBF) testing and fracture criteria development.
- Modified "15-flange Die" for use in evaluating stretch-flanging capability of DP materials.
  - Demonstrated equations provided by B. Levy March 2007 report to be a good starting point for modeling.
- Next steps include:
  - Improved evaluation of microstructure effects.
  - Include effect of shear-affected zone caused during trimming.
  - Optimize process for best edge-stretchability and maximum tool life.

DP980 – 1mm flange

DP980 – 5mm flange

PROJECT RESULTS

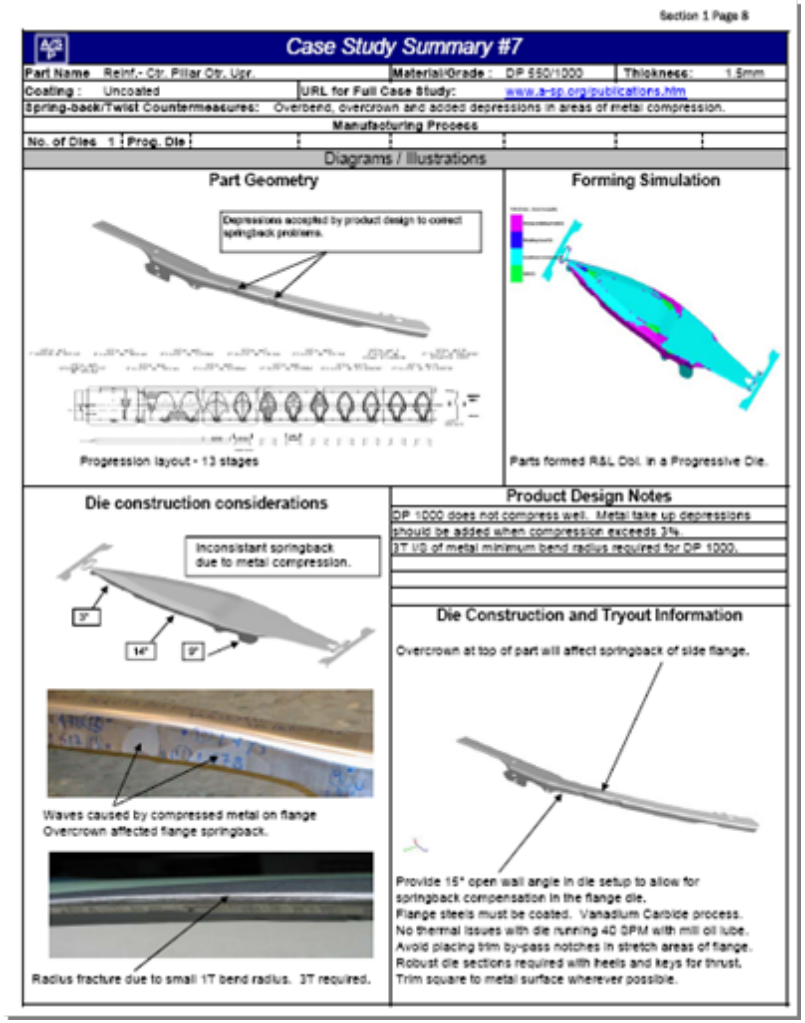
Auto/Steel Partnership

Advanced High-Strength Steel Product and Process Application Guidelines

A Special Edition of In-Depth AHSS Case Studies

Including Excerpts from the IISI *AHSS Application Guidelines*

Auto/Steel Partnership
Southfield, Michigan
November 1, 2007



Section 1 Page 8

Case Study Summary #7

Part Name: Reinf.- Ctr. Pillar Otr. Upr.		Material/Grade: DP 550/1000	Thickness: 1.5mm
Coating: Uncoated	URL for Full Case Study: www.a-sp.org/publications.htm		
Spring-back/Twist Countermeasures: Overbend, overcrown and added depressions in areas of metal compression.			
Manufacturing Process			
No. of Dies: 1	Prog. Die		

Diagrams / Illustrations

Part Geometry

Depressions accepted by product design to correct springback problems.

Progression layout - 13 stages

Forming Simulation

Parts formed R&L Dbl. in a Progressive Die.

Die construction considerations

Inconsistant springback due to metal compression.

3T

14T

9T

Waves caused by compressed metal on flange
Overcrown affected flange springback.

Radius fracture due to small 1T bend radius. 3T required.

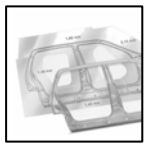
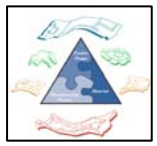
Product Design Notes

DP 1000 does not compress well. Metal take up depressions should be added when compression exceeds 3%.
3T I.D. of metal minimum bend radius required for DP 1000.

Die Construction and Tryout Information

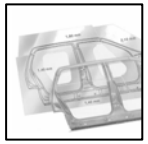
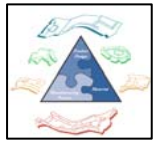
Overcrown at top of part will affect springback of side flange.

Provide 15° open wall angle in die setup to allow for springback compensation in the flange die.
Flange steels must be coated. Vanadium Carbide process.
No thermal issues with die running 40 SPM with mill oil lube.
Avoid placing trim by-pass notches in stretch areas of flange.
Robust die sections required with heels and keys for thrust.
Trim square to metal surface wherever possible.


PROJECT IMPACT

- Successful “proof of concept” for cutting edge applications.
  - DP980 for B-pillar inner panels (not just reinforcements).
  - DP780 & DP980 for complicated rear longitudinal rails.
- New production applications contain key product features identified in this project.
  - Equinox B-pillar reinforcement.
- Documented improvements in correlation of math models of springback with experimental results.

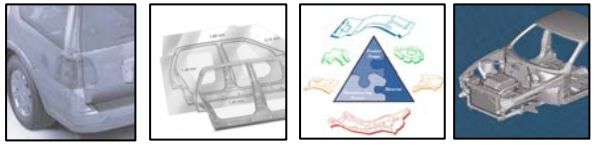

Support of AHSS Applications Guidelines Project:

AHSS Case Studies at http://www.a-sp.org/publications.htm

Technical Papers:

Chrysler rear rail springback correlation study for NUMIFORM.

- Numiform 2007 Conference, Aveiro, Portugal.
- MS&T'07 Conference at COBO Center, Detroit, Michigan
- Forming tonnage study for 2007 SAE Congress in Detroit, Michigan.



Hydroform Materials and Lubricant

Project Manager: Bart Clark
Auto/Steel Partnership

Chair: Ron Soldaat
ArcelorMittal

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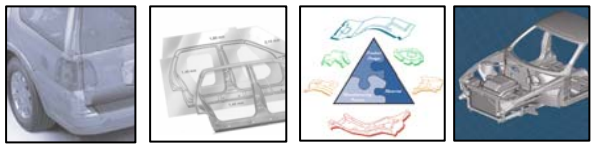
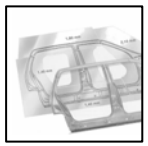
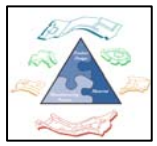


PROJECT GOALS

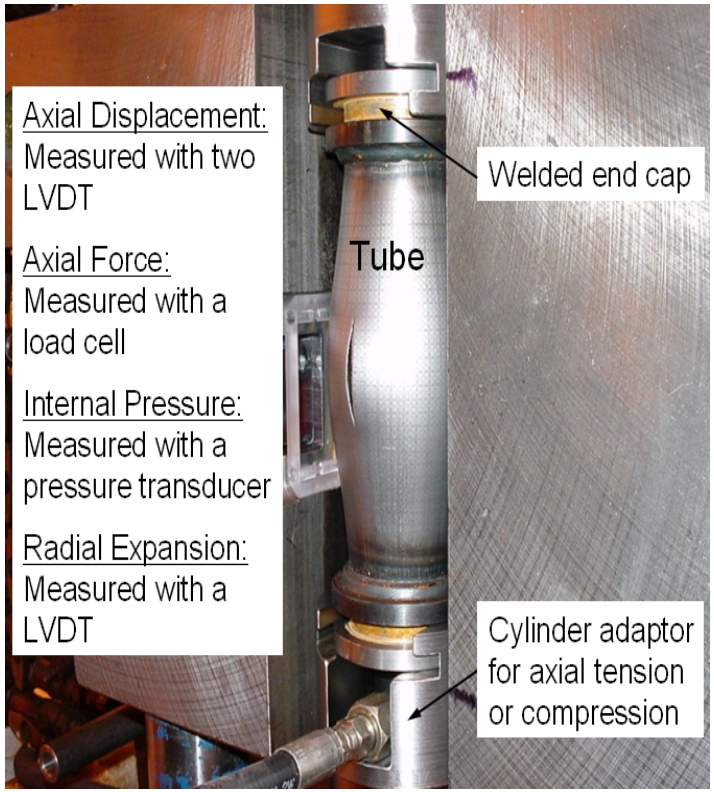
- Explore design, manufacturing and material implications/limitations of tubular hydroforming using advanced high-Strength steel (AHSS).
- Develop in-depth understanding of critical issues pertaining to fabrication of tubes from AHSS.
- Improve advanced CAE tools to streamline hydroforming process design.
- Facilitate the adoption of cutting-edge hydroforming applications in vehicle structures.


PROJECT APPROACH

- Fabricate Tailor Welded Tubes (TWTs) from various grades and gauges of AHSS.
- Using instrumented test facilities, conduct expansion tests of the AHSS TWTs to determine forming limits of roll-formed and seam-welded tubes.
- Shape and hydroform the AHSS TWTs to develop manufacturing guidelines.

Experimental Forming Limits of Steel Tubes



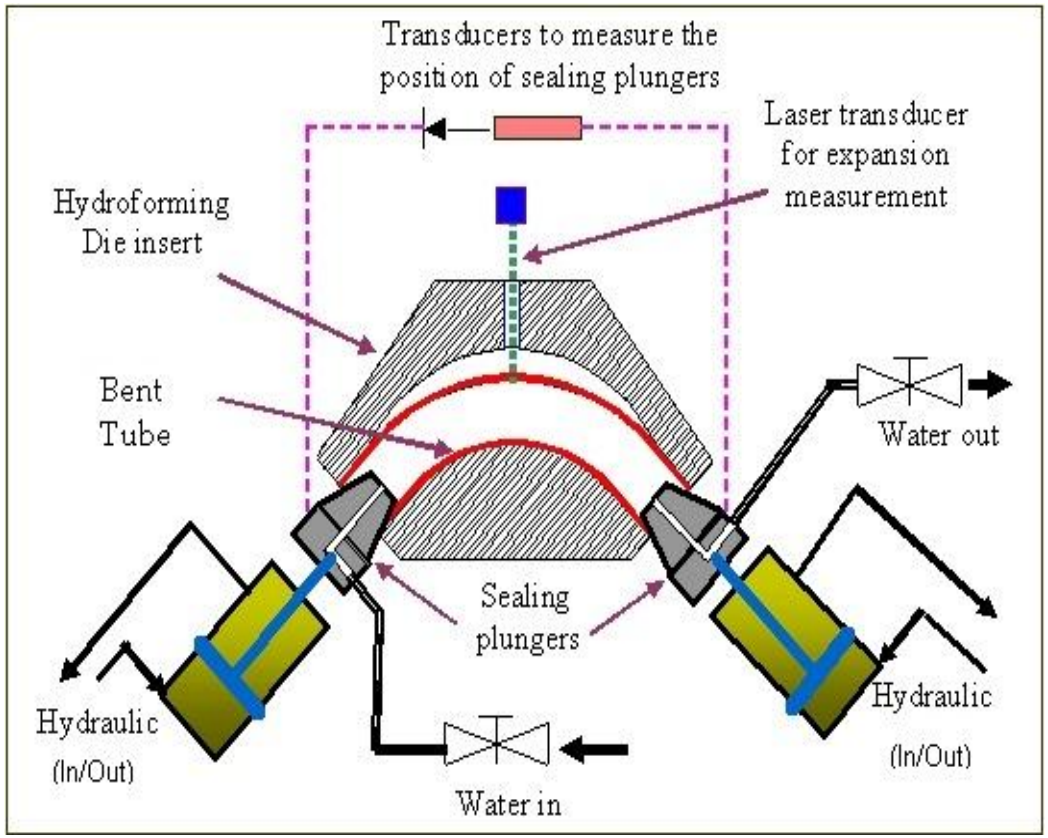
Testing procedures to obtain representative mechanical properties of tubes.

- ***Delivered***

Forming Limit Diagram for tube hydroforming.

- ***Delivered***

Influence of Bending Parameters on the Hydroforming of IF and DP600 Tubes

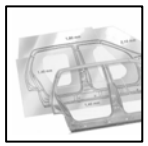
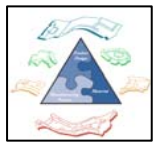


A study on the influence of lubricants and the tube bending process on subsequent hydroforming operations.

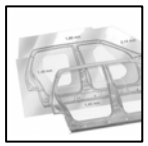
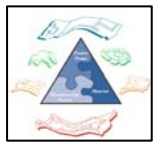
- ***Experimental work complete.***

Forming characteristics of tailor welded tubes.

- ***Experimental work complete.***

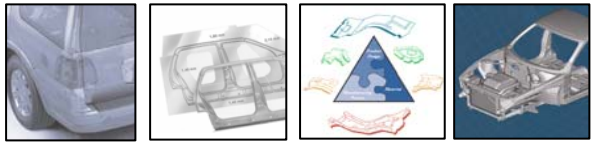

- Engineering reports and presentations placed on A/SP website.
    - Experimental Forming Limits of Steel Tubes
    - Influence of Bending on Hydroforming of IF and DP-600 Tubes
    - FEA Report on Lightweight Front Rail Formability Study
- Ongoing experimental results placed on member's-only area of A/SP website.
- SAE 2009 World Congress technical paper.
- Media relations and public opportunities.


HYDROFORMING MATERIALS AND LUBRICANTS

ACTIVITIES FOR NEXT FISCAL YEAR

- Continue fabrication of AHSS Hydroform TWT Lightweight Front Rails (LWFES concept).
    - Bending trials in process-having difficulties.
    - Hydroform tools built.
- Stress and Strain Measurements under Non-Linear Loading through Tube Fracture for Improved Modeling and Prediction.
    - Project definition and RFQ in process.
- Investigation of Fabricating DP and TRIP Steel Tube from an ERW Production Line.
    - Project initiated with CANMET



Advanced High-Strength Steel Joining

Project Manager: Mike Bzdok
Auto/Steel Partnership

Co-chair: John C. Bohr
General Motors Corporation

Co-chair: Eric Pakalnins
Chrysler LLC

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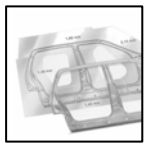
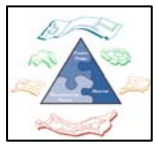
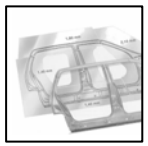
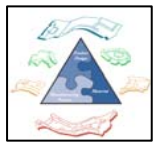




PROJECT GOALS

- Provide welding and joining expertise to support A/SP project teams in developing lightweight automotive body structures.

- Supplement existing welding and joining technical knowledge with applied research to facilitate an increased use of AHSS.

- Utilize A/SP research data to prepare industry weldability and weld quality acceptance standards.

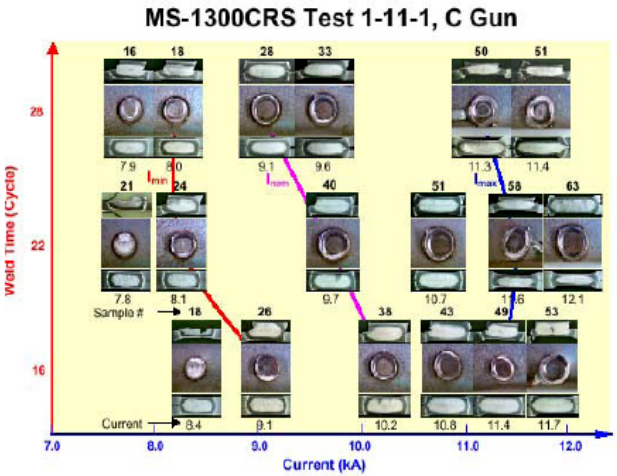




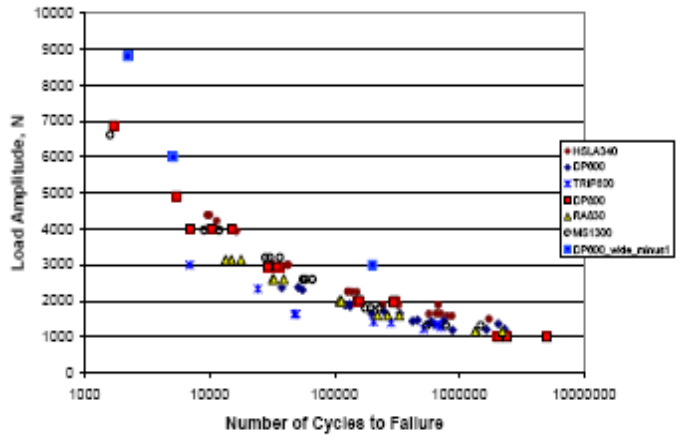

PROJECT DELIVERABLES

- Provide welding process parameters and weld strength data to facilitate increased use of Advanced High Strength Steel (AHSS) in automotive structures.
- Publish common industry standards for weld quality acceptance.
- Publish common industry test methods for evaluating the weldability of automotive sheet steel materials.
- Assess manufacturing feasibility of joining AHSS with single sided processes, projection welding and drawn arc stud welding.

PROJECT DELIVERABLES

Completed Investigation of Resistance Welding Performance of Advanced High-Strength Steels Design of Experiment.





TENSILE SHEAR TEST RUN SHEET # 1 OF 4

Coupon number	Coupon Type	Factor Settings: Button Diameter	Factor Settings: Hold time	Weld Schedule: Tap	Weld Schedule: %Ht. or %Curr.	Weld Schedule: Weld Current (kA) Prog./Act.	Weld Responses: Indent - side 1 (MM)	Weld Responses: Indent - side 2 (MM)	Weld Responses: Peak Load (kN)	Weld Responses: Energy (J)	Weld Responses: Fracture Face (AWS)	Weld Responses: Pre-Test Cracks	Weld Responses: Post-Test Cracks	Extras held by:
A. Install new caps as per AWS D8.9														
B. Condition caps as per AWS D8.9, using 22 cycles weld time, and the same force as used in DP600 Lobe work														
C. Setup schedule to achieve the button diameter requirement at the hold time specified														
D. PERMANENTLY identify each sample (use scribing tool)														
E. Weld & distribute each sample into a container and ready for shipment to appropriate supplier														
1	Met work	4.9	90	1	46%	11.5	0.04	0.11	NA	NA	NA	NO	NA	RES
2	Impact	4.9	90	1	46%	11.4	0.05	0.05	4.97	28.68	7	NO	NO	RES
3	Impact	4.9	90	1	46%	11.4	0.04	0.04	12.29	23.13	7	NO	NO	RES
4	Impact	4.9	90	1	46%	11.4	0.06	0.08	-	32.69	7	NO	NO	RES
5	Extra Impact	4.9	90	1	46%	11.3	0.05	0.08	13.97	18.54	7	NO	NO	RES
6	Impact	4.9	90	1	46%	11.4	0.06	0.06	NA	NA	NA	NO	NA	RES
7	Impact	4.9	90	1	46%	11.3	0.05	0.06	13.20	16.50	7	NO	NO	RES
8	Extra Impact	4.9	90	1	46%	11.3	0.06	0.09	NA	NA	NA	NO	NA	RES
9	Met work	4.9	90	1	46%	11.5	0.05	0.12	NA	NA	NA	NO	NA	RES
10	Met work	4.9	90	1	44%	11.0	0.01	0.02	NA	NA	NA	NO	NA	RES
11	Static	4.9	90	1	44%	10.9	0.06	0.04	11.22	22.02	7	NO	NO	RES
12	Static	4.9	90	1	44%	10.9	0.06	0.07	11.21	26.26	7	NO	NO	RES
13	Static	4.9	90	1	44%	10.9	0.04	0.06	12.21	31.30	7	NO	NO	RES
14	Extra Static	4.9	90	1	44%	10.9	0.05	0.10	NA	NA	NA	NO	NA	RES
15	Static	4.9	90	1	44%	10.9	0.04	0.06	11.24	28.79	7	NO	NO	RES
16	Static	4.9	90	1	44%	10.9	0.05	0.07	10.24	27.77	7	NO	NO	RES
17	Extra Static	4.9	90	1	44%	10.8	0.05	0.06	NA	NA	NA	NO	NA	RES
18	Met work	4.9	90	1	44%	10.9	0.02	0.02	NA	NA	NA	NO	NA	RES
19	Met work	4.9	90	1	44%	10.9	0.02	0.04	NA	NA	NA	NO	NA	RES
20	Fatigue	4.9	90	1	44%	10.8	0.06	0.06	NA	NA	NA	NO	NA	RES
21	Fatigue	4.9	90	1	44%	10.8	0.05	0.07	NA	NA	NA	NO	NA	RES
22	Fatigue	4.9	90	1	44%	10.8	0.08	0.06	NA	NA	NA	NO	NA	RES
23	Extra Fatigue	4.9	90	1	44%	10.7	0.07	0.06	NA	NA	NA	NO	NA	RES
24	Fatigue	4.9	90	1	44%	10.9	0.05	0.09	NA	NA	NA	NO	NA	RES
25	Fatigue	4.9	90	1	44%	10.7	0.06	0.07	NA	NA	NA	NO	NA	RES
26	Extra Fatigue	4.9	90	1	44%	10.8	0.05	0.05	NA	NA	NA	NO	NA	RES
27	Met work	4.9	90	1	44%	10.8	0.13	0.09	NA	NA	NA	NO	NA	RES

RESULTS & CONCLUSIONS

Part I - Peak Load

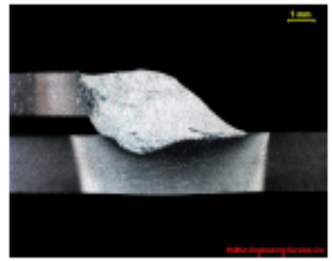
- In general, high loading rate (A) results in high peak load, which could be related to the strain-rate effect of the tested materials. Exceptions are Materials 09 and 10. Material 09 is not sensitive to loading rate, and Material 10 has a negative loading rate effect which indicates that a high loading rate produces a lower peak load. Among the materials tested, Materials 07 and 11 are most (positively) sensitive to the loading rate.
- Increasing weld button size (B) dramatically increases the peak load for most of the materials. The responses of Materials 07, 09, and 11 are not as strong as other materials.
- Hold time (C) has in general positive effects on peak load. The effects are not as significant as for the loading rate and button diameter, and Materials 05, 06, and 09 are not sensitive to the hold time.
- The interactions of factors are generally weak or negligible.

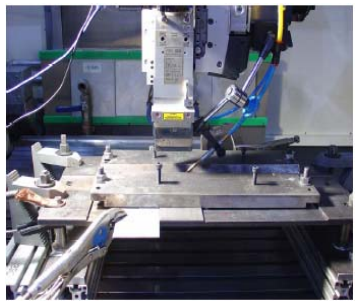
Mat No.	Effects: A	B	C	AB	AC	BC	ABC
01	+	+++	+	O	O	O	O
2A	++	+++	+	O	O	O	+
3A	+	+++	++	++	+	+	+
05	++	+++	O	O	O	O	O
06	++	+++	O	O	O	O	O
07	+++	+	++	O	+	O	O
08	+	+++	++	+	O	O	O
09	O	++	O	O	O	O	O
10	--	+++	+	---	-	+	-
11	+++	++	+	+	O	-	-
12	++	+++	+	+	O	-	O
13	+	+++	+	++	+	+	+

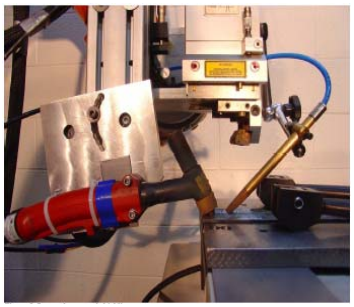
For each material, the peak load and energy are analyzed as functions of loading rate, button diameter, and hold time.

PROJECT DELIVERABLES

Completed Study of Single Sided Weld Processes for Joining Advanced High-Strength Steel.







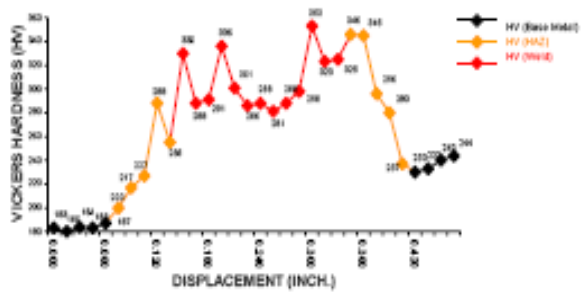
MIG AC Welding Material Combination 8

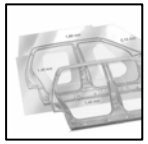
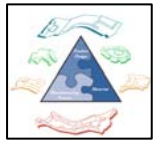
Parameter	Value
Travel speed	30 ipm (762 mm/min)
Wire Spec	ER90S-D2
MIG current	120A
Wire feed rate	290 in/min (7.37 m/min)
Weld Volts	21 V
Gap (engineered)	

Tensile shear Strength		
	Load kN	Energy J
Min	33.10	100.02
Average	33.37	105.59
Max	33.64	112.46

Impact Strength		
	Load kN	Energy J
Min	53.1	467.9
Average	65.4	495.1
Max	104.1	508.7

VICKERS HARDNESS CHART




ADVANCED HIGH-STRENGTH STEEL JOINING

PROJECT DELIVERABLES

Investigated the use of process finite element modeling to predict weld quality characteristics and optimize weld process parameters for resistance spot welding of AHSS.

SORPAS (R) Version 6.0 Enterprise Edition
Copyright (C) 1995-2005 by SWANTEC Software and Engineering ApS. All rights reserved.

Simulated with: SORPAS (R) Version 6.0 **Simulation finished:** 16-09-2005 16:46:23

Report of Simulation

Filename: C:\SORPAS 6.0 Enterprise\Work\jon bohr project\FB-25 48mm DP800GA 65mm.dat
Problem ID: FB-25 4.8mm DP 800 coated 3pulse 6.5mm nugget **Computation time:** 0:55:15
Note: AC current geometry test 1.6mm zn coated sheet GM parameters **Number of Elements:** 873

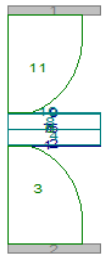
Materials:

Electrodes:
(3) [Copper_Water cooled]
(11) [Copper_Water cooled]

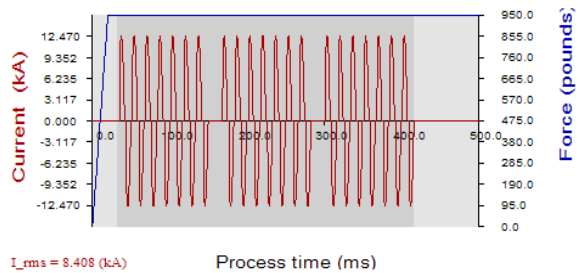
Workpieces:
(4) [DP 800]
(8) [DP 800]

Coatings:
(2) [Galvaneal]
(5) [Galvaneal]
(7) [Galvaneal]
(9) [Galvaneal]

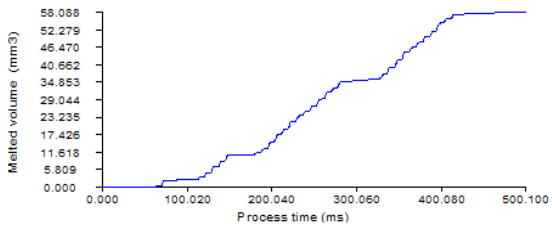
Design of Combination:



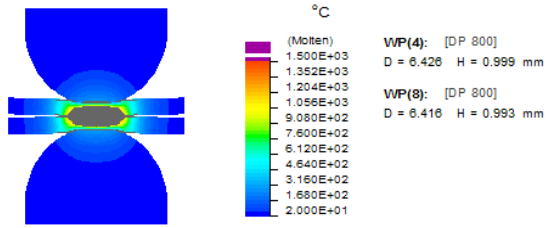
Process Parameter Settings:

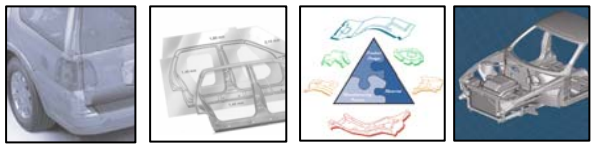


Simulation Result - Process Parameter Curve:



Simulation Result - Temperature Distribution and Weld Nugget:





PROJECT DELIVERABLES

Weld Lobe Development and Assessment of Weldability of Common Automotive Fasteners (Studs and Nuts) to AHSS Using the Drawn Arc Welding Process

AUTO STEEL PARTNERSHIP - DRAWN-ARC WELDING STUDY 2006

Emhart Teknologies

FASTENER DESCRIPTION:	M6 Stud/Nut
FASTENER PLATING:	Zinc-Nickel
EMHART FASTENER PART#:	39050
BASE MATERIAL TYPE:	DP980
BASE MATERIAL PLATING:	Galvaneal
BASE MATERIAL THICKNESS:	1.0 mm

WELD CURRENT (I) in Amps	20	25	30	35	40	45	50	55	60
1500									
1450									
1400									
1350									
1300									
1250			5	5	5	5			
1200			5	5	5	5			
1150			5	4	5	5			
1100			2	5	5	5	5		
1050			5	5	5	4	5		
1000			1	5	5	5	5		
950			2	5	5	4	5		
900			3	1	5	3	5		
850			2	1	1	4	5		
800			1	1	1	2	1		
750			1	1	1	1	5		
700			1	1	1	1	4		
650									
600									
550									
500									

WELD TIME (t) in milliseconds

EQUIPMENT

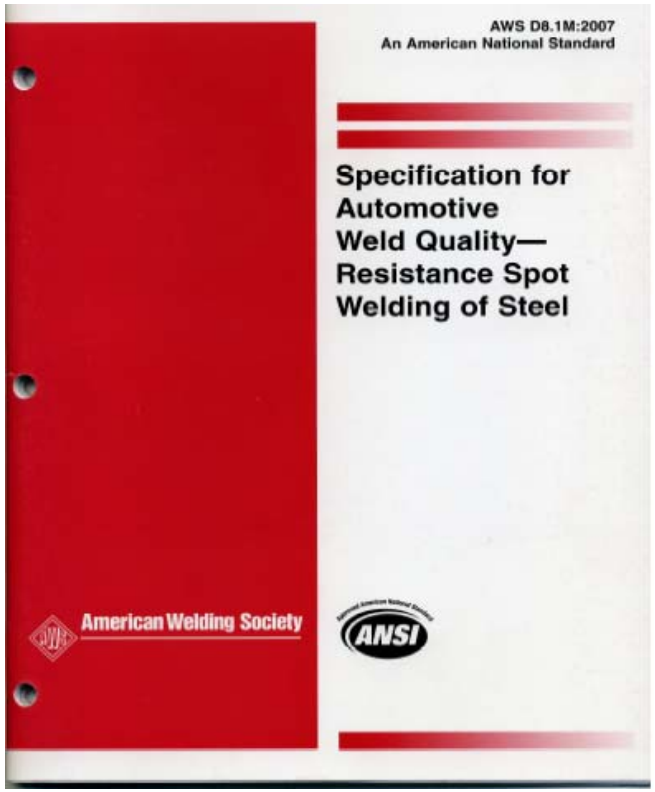
DCE 1500 WELD CONTROL
ETF12 FEEDER
LM WELD HEAD

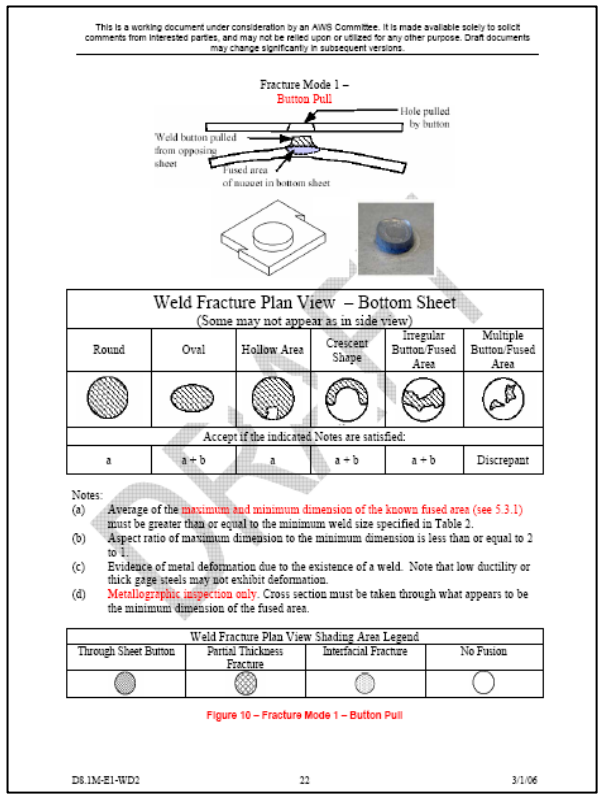
WELD PROGRAMMING PARAMETERS

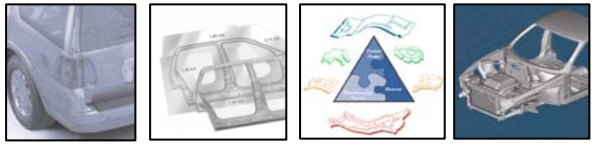
LIFT	1.20mm
PENETRATION	-1.8 mm
START DELAY	250ms
Varc PILOT LIMIT	15.0V to 33.0V
Varc WELD LIMIT	15.0V to 33.0V
WELD TIME	+/- 6ms
WELD CURRENT	+/- 30Amps
STUD NEGATIVE POLARITY	

PROJECT DELIVERABLES

A/SP Task Group Prepared AWS D8.1M: 2007 Standard for Resistance Spot Weld Acceptance Criteria.

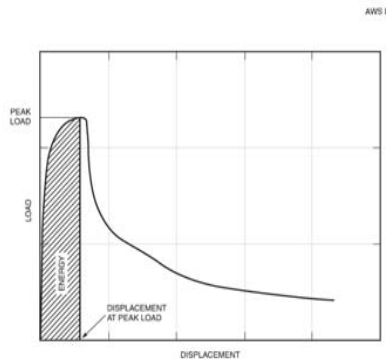


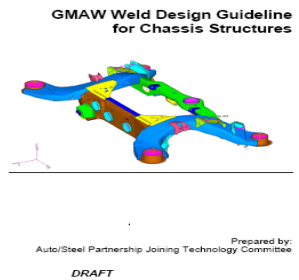


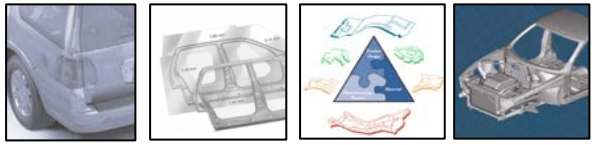


ACTIVITIES FOR 2008

- Joint Efficiency Project
  - Welds/joints/bonds on lap-shear coupons to generate tensile test (load-displacement) curves.
  - Five grades of steel to quantify joint efficiencies of forty joining and bonding methods.
- LME and Hot Cracking Susceptibility
  - Sigmajig testing of AHSS
- Procedure for RSW Characterization
  - AWS D8.9 Procedure for AHSS
- GMAW Weld Design Guideline



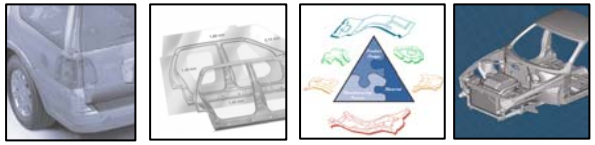




TECHNOLOGY TRANSFER

- Technical presentations and reports are presented to the Joining Technology Team and placed on www.a-sp.org, for team member access and distribution.

- Selected projects presented at AWS Sheet Metal Welding Conference, International Auto Body Congress and the Material Sciences & Technology Conference.
- Presentations and exhibit at GDIS.
- The A/SP prepared industry standards are published by AWS/ANSI.
- Final reports are available on the public side of the A/SP website

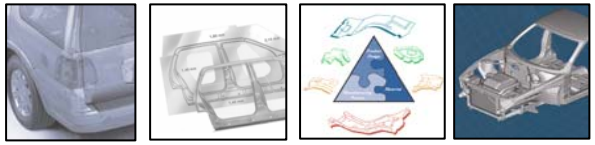


Tribology

Project Manager: Pat Villano
Auto/Steel Partnership

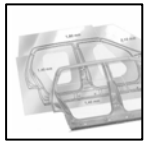
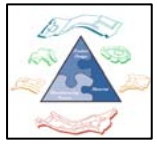
Chair: David Meuleman
General Motors Corporation

This presentation does not contain any proprietary or confidential information



PROJECT GOALS

- Investigate the influence of lubricants, die treatments , and designs on reducing the wear when using Advanced High Strength Steels (AHSS)
- Assess variables such as coefficient of friction, sheet metal grade and thickness, die material grade and coating, Temperature, and restraining forces on die wear.
- Use draw bead penetrations and parameters in the Continuous Wear Test (CWT) to model production practices.
- Testing materials using design of experiments methods will define trends and increase accuracy of model.


APPROACH

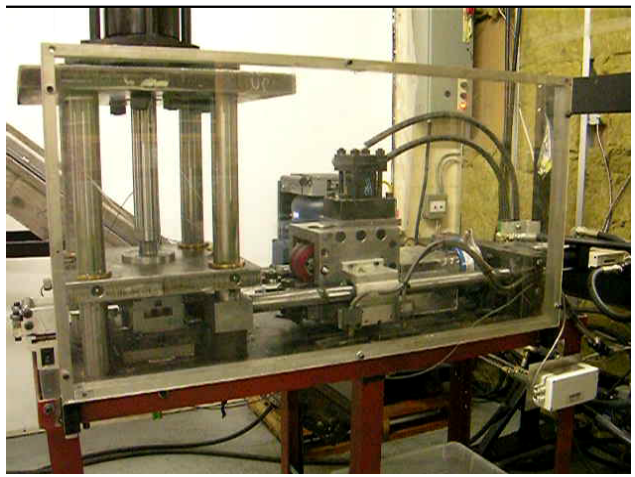
- Complete wear studies involving:
  1. Steel strength levels and coatings.
  2. Die (draw bead) material and coating.
  3. Lubricants.
  4. Die geometry.
  5. Sheet thickness.

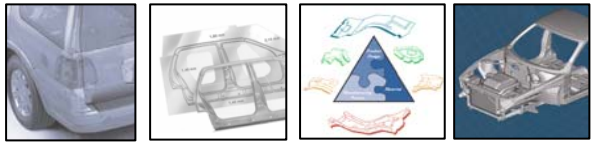
- Conduct studies of tool steels used for trim dies.

- Complete One-factor at a time (OFAT) testing examining DP780 & DP980 steel at 100,000 hits.

TOOL WEAR TEST APPARATUS

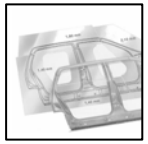
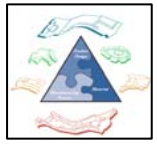
- Decoiler
- Coil
- Main Ram
- Pull Cylinder
- Clamp/Cut Ram
- Thermocouples (3)
- Bead inserts
- Load cell





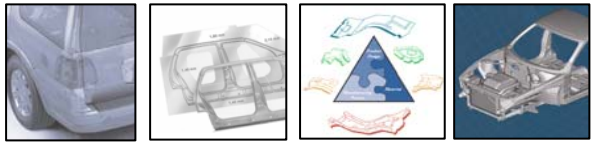
L16 DESIGN OF EXPERIMENTS

Test #	Seq #	Sheet Coating	Base Steel	Bead Radius (mm)	Lube	Bead Coating	Thickness (mm)	Actual Thickness (mm)
1	4	GA	DP600	5	DF	D2	1.2	1.19
2	7	GA	DP600	5	DF	CrN	1.6	1.60
3	16	GA	DP600	7	MO	D2	1.2	1.18
4	8	GA	DP600	7	MO	CrN	1.6	1.60
5	11	GA	HSLA	5	MO	D2	1.6	1.66
6	14	GA	HSLA	5	MO	CrN	1.2	1.21
7	6	GA	HSLA	7	DF	D2	1.6	1.67
8	13	GA	HSLA	7	DF	CrN	1.2	1.21
9	12	GI	DP600	5	MO	D2	1.6	1.57
10	3	GI	DP600	5	MO	CrN	1.2	1.16
11	9	GI	DP600	7	DF	D2	1.6	1.59
12	15	GI	DP600	7	DF	CrN	1.2	1.18
13	2	GI	HSLA	5	DF	D2	1.2	1.20
14	10	GI	HSLA	5	DF	CrN	1.6	1.63
15	1	GI	HSLA	7	MO	D2	1.2	1.21
16	5	GI	HSLA	7	MO	CrN	1.6	1.59

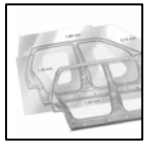
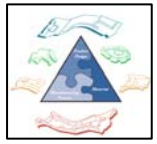

OFAT Test Specifications

Variable	Expected Low Abrasive Wear	Expected High Abrasive Wear
Sheet Coating	Hot-Dipped Galvanized (GI)	Galvanneal (GA)
Base Steel	HSLA	DP600
Bead Radius	7mm	5mm
Lubricant	Dry Film (DF)	Mill Oil (MO)
Bead Coating	CrN on D2	Uncoated D2
Thickness	1.2 mm	1.6 mm



TECHNOLOGY TRANSFER

- Four technical papers scheduled for publication.
- Update A/SP “Procedures for Testing Characteristics of Automotive Sheet Steel Lubricants.”
- Report out the results of OFAT including extended testing (100,000 strokes) of best performing die material/die coating combination.


ACTIVITIES FOR NEXT FISCAL YEAR

- Evaluation of five trim steel/coating combination using DP980 steel.
- Descriptive wear model based on all tribology testing, including galvaneal and hot dip galvanized effect.
- Develop/publish a predictive wear model.
- Continue partnership with NIST on AHSS Tribology issues.